Space Technology Research Grants

Use of the Mars Atmosphere To Improve Performance of Supersonic Retropropulsion

Completed Technology Project (2012 - 2017)

Project Introduction

Landers and rovers have been critical for the exploration of Mars. While past missions have been successful, we are reaching the extent of what we can land on Mars using incremental advances of Viking-technology, placing limitations on the mass, landing location and accuracy of the entry vehicle. In order to send more massive rovers to Mars it is necessary that we develop new technologies to increase our atmospheric entry and landing capabilities. This is needed in order to enable future human-precursor and human-scale missions to Mars. One possible technology to enable future high mass missions to Mars is the use of Supersonic Retropropulsion (SRP). SRP involves using thrusters directed in opposition to the oncoming airflow to decelerate the entry vehicle while it is traveling at supersonic speeds. Because of the propellant and oxidizer mass required for the additional thrusters, currently proposed SRP configurations require a significant increase in performance and efficiency before they can be considered an effective solution for Mars missions. A possible means to improve SRP performance and mass-efficiency is the use of an atmospheric-breathing propulsion system for the SRP thrusters. An atmospheric-breathing propulsion system, unlike a conventional rocket propulsion system, does not carry the oxidizer within the craft itself. It instead ingests the oxidizer from the surrounding atmosphere and combines it with the fuel carried onboard to create thrust. Because the oxidizer is not carried within the vehicle this significantly reduces the mass and volume requirements of the entry system. In the case of a Mars lander, this oxidizer would have to be carried throughout the entirety of the mission (from Earth departure until Mars descent); as such, its elimination from the vehicle may result in a significant performance advantage. A significant challenge with using an atmospheric-breathing propulsion system on Mars is that the Mars atmosphere consists largely of CO_2, not air. Thus, traditional oxygen combustion is not possible. Instead, innovative combustion techniques need to be developed that allow for combustion using CO_2 as an oxidizer. The initial feasibility of such systems has been demonstrated such as the production of thrust from the combustion of Magnesium powder and other fuels with CO_2. These initial efforts demonstrate that an atmospheric-breathing SRP system on an Entry, Descent and Landing (EDL) vehicle may be possible. The objective of this project is to design and demonstrate the feasibility of an atmospheric-breathing supersonic retropropulsion descent system for use on a Mars entry vehicle. The resulting descent system would effectively integrate three technological developments: supersonic retropropulsion, atmospheric-breathing propulsion and CO_2 based combustion in an integrated vehicle design process. Development of the integrated system will involve propulsion and vehicle design to first develop a feasible atmospheric-breathing propulsion system utilizing the Mars atmosphere and second, integrate that system within an entry vehicle as a cohesive and robust EDL system. This involves designing a configuration that is able to efficiently collect the Mars atmosphere and transport it to the thrusters while maintaining a thruster configuration that provides sufficient deceleration and control throughout the descent.

Project Image Use of the Mars Atmosphere To Improve Performance of Supersonic Retropropulsion

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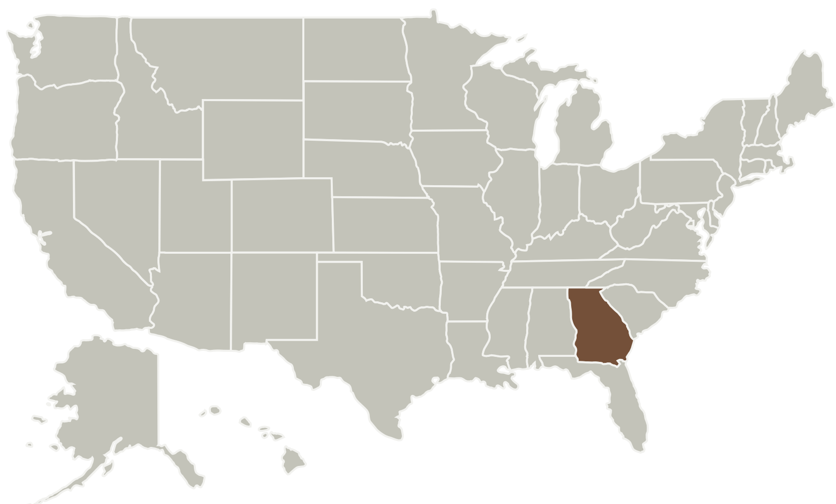
Supporting the system design will be computational analysis in addition to small-scale experimental work. The advantage of this integrated EDL solution is to increase the current capabilities of Mars landers so that they can achieve a wider range of landing sites, land with greater precision and land higher mass payloads The descent system will be designed to support high mass payloads and enable future human-scale missions to Mars.

Anticipated Benefits

The advantage of this integrated EDL solution is to increase the current capabilities of Mars landers so that they can achieve a wider range of landing sites, land with greater precision and land higher mass payloads The descent system will be designed to support high mass payloads and enable future human-scale missions to Mars.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Georgia Institute of Technology-Main Campus(GA Tech)	Lead Organization	Academia	Atlanta, Georgia

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Georgia Institute of Technology-Main Campus (GA Tech)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Robert D Braun

Co-Investigator:

Keir Gonyea

Primary U.S. Work Locations

Georgia

Images

11492-1363268243771.jpg
Project Image Use of the Mars Atmosphere To Improve Performance of Supersonic Retropropulsion
(https://techport.nasa.gov/image/1841)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  └ TX09.2 Descent
    └ TX09.2.2 Supersonic Retropropulsion

Target Destination

Mars